Several Aspects of Internet and Web-Based Technology in Diabetes Management

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As evidenced by a large number of well-conducted randomized trials, the complications and confounding conditions that can result from mismanagement of diabetes can be reduced or prevented with appropriate medical care (1–5). Observational studies to ascertain the level of glycemic control, blood pressure control, and cholesterol control in people with diabetes provide evidence of poor adherence to established self-management protocols (6–9). Although diabetes shares characteristics with other chronic lifelong diseases that require a model of continuous care, successful management of diabetes is primarily based on patients' ability to maintain consistency in self-care–related behaviors (10–14). Diabetes care requires long-term self-management and a willingness to adapt to a new lifestyle, which includes changes in eating habits, regular exercise, and adherence to medication schedules (15–19). Thus, diabetes health care providers have limited control over the actual development and treatment of the disease (20–24).

Challenges in Diabetes Treatment and Management

Lack of adherence to diabetes self-care protocols is multifaceted but includes factors such as perceived lack of time for check-ins and follow-ups with primary care providers (PCPs), treating providers, and specialist (25). In addition to patient complexities, some strategies used by treating providers and specialists for providing self-management classes or interventions have shown promise but are limited by costs to both education/intervention providers and patients. For providers, costs may include staffing, conducting classes, and securing locations for them; for patients, costs may include transportation, missed time from work, and childcare services. An additional barrier is providers' inability to provide frequent, long-term contact with patients who have completed such interventions; there are limited available resources to devote to sustaining lifelong intervention to encourage adherence to effective self-management practices (26,27).

PCPs normally serve as the central point of care and arrange for patient appointments with other specialists such as nutritionists, podiatrists, and ophthalmologists. Although this model of care has proven effective for pharmaceutical interventions, it has not proven as effective for the multifaceted layering of care required for the self-management of chronic diseases such as diabetes. Limitations of this care model include inadequate patient contact and follow-up and difficulty for PCPs to stay up-to-date on patients' adherence to their medication regimen and maintenance of lifestyle changes (28–31).

The effectiveness of diabetes management and treatment protocols can be negatively influenced by the costs of care, inconvenience, and lack of accessibility of clinicians and clinical treatment and learning sites.

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However, some evidence suggests that these barriers can be overcome through the use of technology, and specifically Internet- and Web-based services (32,33). As part of a more patient-centric model of care, patients can use Internet- and Web-based tools to monitor their own behaviors, provide status updates to their care providers regarding adherence to self-management protocols, and plan for any needed changes to their self-management or care protocols based on current biometric, laboratory, and behavioral data (34–36).

Supporting Research

Three studies are described below as representative examples of the potential use of Internet- and Web-based services in the provision of diabetes care.

Study 1

In a study published in 2012 (25), 52 nursing staff members with 1–12 years of clinical experience were recruited to determine the acceptability of a nursing informatics training program called the Diabetes Care Support (DCS) system. The system was designed to deliver scenario-based training on daily activities to promote self-management of diabetes and the collection of patient data needed to develop care plans.

The DCS was provided as a "lightweight" (simple and intuitive) health care application to enhance care support and provide facilitated operations to help nurses manage their patients' condition and coordinate provider care. The tool was developed to mimic the dynamic state of patient self-care activities and health issues and to offer technical solutions through patient and care manager side functions and operations required as a part of patient care duties. A team of multidisciplinary researchers, including physicians, diabetes educators, and technical experts, elicited functional requirements for the application from eight people with type 2 diabetes and used their responses to inform the tool's development.

The DCS was developed using open-source code—software coding often developed as a public collaboration and made freely available for public use—and was available for deployment on various electronic devices, including computers, mobile phones, smartphones, and personal data assistants. It comprised social and community features (interactive and often Web-based tools used to retrieve, store, and present information), including a widget and Rich Site Summary (RSS) tools, allowing for patient-based functions such as creating personal self-care content, receiving diabetes care news feeds, and optimally interacting with the application. Care manager functions and tools built into the system included blogs and Website tools to deliver patient self-care status, identify risks that require attention or intervention, and maintain patient contact to enable relationship-building.

Of the 52 nurses recruited to test the system, 42 (80.8%) provided feedback. The DCS was found to be useful in daily operations and easy to use and integrate into their practice to effectively support chronic disease management.

The Technology Acceptance Model (TAM) was used to evaluate participants' level of acceptance of the application (25). The TAM is a questionnaire exploring the perception of ease of use and overall utility. It included 23 questions: 10 on demographics (e.g., participants' age, profession, and experience with technology), 6 on ease of use, 5 on usefulness, and 2 on intention to use the system. The 42 responders were 22–48 years of age, 90% had ≥1 year of clinical nursing experience, and 13 were in active chronic disease management positions. Analysis of their response data suggested that respondents perceived the DCS to be a useful tool in carrying out their patient care activities.

Study 2

In another prospective, randomized, controlled trial (37), 80 patients with type 2 diabetes were studied to determine whether A1C reduction could be achieved using an Internet-based glucose monitoring system (IBGMS). The study found that use of an IBGMS was capable of and superior to other in-office care systems for stabilizing and reducing A1C levels.

Over the course of 30 months, participants used this bidirectional communication tool, which was designed to connect online and offline systems and facilitate the doctor-patient relationship. The tool also connected patients with educational opportunities and elicited their feedback.

Participants in the intervention group (n = 40) logged on to the IBGMS at any time to provide their glucose levels, whereas those in the control group (n = 40) provided updates on their glucose levels only at in-office visits every 3 months. All participants were required to be screened by Kangam St. Mary's Hospital Diabetes Center staff for their weight, height, blood pressure, and A1C at the beginning of the study. All participants (intervention and control) attended in-office visits with their care provider every 3 months, at which they were screened for comparative biometrics, including A1C.

All participants received a baseline diabetes management orientation course and glucose meters for home use. The intervention group also received training on the IBGMS they would use throughout the study to track their biometric data and communicate with their care provider. In addition to providing their glucose data through the IBGMS, the intervention group also used the tool to communicate with their care provider about changes in their diet or exercise habits, hypoglycemic episodes, and other factors that might have an impact on their glucose level. Their care providers were able to use

the system to provide near-real-time feedback on the participants' updates.

Of the 80 subjects, 71 participated for the duration of the study and were included in the analysis. At the end of the study, mean A1C was significantly lower in the intervention group (A1C decreased from a baseline of 7.7 ± 1.5% to 6.9 ± 0.9% at study end in the intervention group; in the control group, A1C was 7.5 ± 1.3% at baseline and 7.5 ± 1.0% at study end). This and subsequent studies (38) have shown that use of the IBGMS tool is superior to conventional office-based diabetes care models for controlling blood glucose.

Study 3

Another randomized clinical trial (38), in which hospital outpatients used an IBGMS, provides additional evidence in support of the potential effect of Internet- and Web-based technologies on diabetes management. In this study, 110 patients received outpatient management through the IBGMS for 12 weeks, whereas a control group received usual outpatient management consisting of in-person and onsite care and education appointments two to three times during the 12-week period. A1C and other laboratory tests were performed for all patients at the start and end of the study.

Participants in the IBGMS group were instructed to input their glucose readings (taken before and after meals) to the online system at their convenience. They were also instructed to input dosage and frequency information for their medications and were given the option to input additional biometric data such as their blood pressure and weight. These patients frequently received recommendations from their care providers regarding adjustments to their care plan based on the information they input to the IBGMS.

At the end of the study, the difference in A1C between the intervention and control groups was vast. In the intervention group, mean A1C decreased from 7.59 to 6.94%. Changes in A1C in the control group were not significant (7.59–7.62 ± 0.13%). The researchers concluded that the IBGMS can be an effective tool in improving diabetes management in that it facilitates more frequent patient-provider contact in the form of virtual interactions and allows patients to receive timely medical advice based on current or evolving conditions. These factors also serve to stimulate and motivate patients' adherence to prescribed diabetes self-management protocols.

Summary and Conclusion

The traditional provision of diabetes care includes regular clinical visits, which include monitoring A1C and risk factors such as LDL cholesterol and blood pressure; performing foot care examinations; and making necessary changes to medications and dosing schedules. However, online services are a low-cost option to expand the reach and depth of patient-provider interactions and enhance continuity of care (27,39). Conversation, follow-up, information-sharing, and regimen adjustment can now be accomplished through Internet- and Web-based technologies, thus reducing or alleviating scheduling issues, cost concerns, and patients' burden of traveling to in-person visits (27,31). Although the overall effectiveness of traditional diabetes management and treatment protocols can be negatively influenced by high costs of care, inconvenience, and poor accessibility to clinics and learning sites, there is strong evidence suggesting that these barriers can be overcome through the use of technology, and specifically through the employment of Internet- and Web-based services (32,33).

Internet- and Web-based solutions provide a new paradigm through which traditionally incremental physician-centered care can take on a more fluid, real-time, and patient-centric form. These technologies enhance educational resources and data-gathering efforts to improve resources and encourage more effective diabetes self-management between clinic visits (35). These technologies can be used to enhance provider functions, automate appointment and medication reminders, serve as a platform for electronic food and medication diary tools, and provide patient-centered functions such as connection to peer support groups and provision of self-paced or instructor-led diabetes self-management education. These technologies offer great promise for improving diabetes management through convenient online services that connect patients directly with their provider and facilitate more real-time disease management. Physicians and other diabetes care providers can use these new capabilities to help their patients better manage their chronic disease (40,41).

Duality of Interest

No potential conflicts of interest relevant to this article were reported.

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